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Predictors of post-operative surgical site infection following elective and emergency abdominal surgeries: A prospective observational study

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Abstract:
Surgical site infection (SSI) is one of the most frequent post-operative complications following abdominal surgery and contributes substantially to patient morbidity, prolonged hospital stay and increased healthcare costs. Therefore, it is of interest to evaluate the predictors of post-operative surgical site infection among patients undergoing elective and emergency abdominal surgeries. A prospective observational study was conducted over 18 months in a tertiary care hospital among 200 patients and demographic, clinical, operative and post-operative variables were collected and analyzed using appropriate statistical methods. Surgical site infection developed in 18.5% of patients and was significantly associated with emergency surgery, diabetes mellitus, obesity, anemia, prolonged operative duration, contaminated or dirty wounds and longer preoperative hospital stay ($p<0.05$). Thus, early identification and optimization of these risk factors, along with adherence to evidence-based infection prevention measures, may reduce the incidence of surgical site infection and improve post-operative outcomes.

Keywords: Surgical site infection (SSI), abdominal surgery, elective surgery, emergency surgery, post-operative complications, predictors, risk factors, prospective observational study

Background:
Surgical site infection (SSI) is among the most common healthcare-associated infections and remains a major cause of post-operative morbidity, prolonged hospitalization, increased healthcare expenditure and delayed recovery despite advances in surgical techniques and infection prevention strategies. Abdominal surgeries are particularly associated with a higher risk of SSI because of the potential contamination from the gastrointestinal tract and the complexity of many operative procedures **[1, 2]**. The incidence of SSI varies according to patient characteristics, wound classification, operative duration, emergency status and institutional infection control practices. Patients undergoing emergency abdominal surgery generally have a greater risk of post-operative infection than those undergoing elective procedures because of delayed presentation, contamination, inadequate preoperative optimization and underlying physiological derangements **[3, 4]**. Several patient-related factors, including advanced age, diabetes mellitus, obesity, anemia, malnutrition, smoking and other comorbid illnesses, have been identified as important determinants of post-operative SSI. Likewise, surgery-related variables such as prolonged operative time, contaminated or dirty wounds, blood loss, duration of preoperative hospital stay and inappropriate antibiotic prophylaxis significantly influence the occurrence of infection **[5, 6]**. Early identification of these modifiable and non-modifiable risk factors is essential for implementing preventive strategies, improving post-operative outcomes, reducing healthcare costs and enhancing patient safety. However, the relative contribution of these predictors varies across different populations and healthcare settings, emphasizing the need for institution-specific evidence **[7, 8].** Therefore, it is of interest to evaluate the predictors of post-operative surgical site infection following elective and emergency abdominal surgeries in patients treated at a tertiary care hospital.

Materials and Methods:
This prospective observational study was conducted in the Department of General Surgery of a tertiary care teaching hospital over a period of 18 months. Adult patients undergoing elective and emergency abdominal surgeries during the study period were enrolled consecutively after fulfilling the eligibility criteria. The study included 200 patients who underwent elective or emergency abdominal surgical procedures.

Inclusion criteria:
[1] Patients aged 18 years or older.
[2] Patients undergoing elective abdominal surgery.
[3] Patients undergoing emergency abdominal surgery.
[4] Patients willing to participate in the study.

Exclusion criteria:
[1] Patients with pre-existing surgical site infection before surgery.
[2] Patients undergoing minor procedures not requiring formal abdominal incision.
[3] Patients lost to post-operative follow-up.
[4] Patients with incomplete clinical or operative records.

Data collection:
Baseline demographic characteristics, body mass index, comorbidities, smoking status, hemoglobin level, serum albumin, indication for surgery, type of surgery, wound classification, duration of surgery, American Society of Anesthesiologists (ASA) grade, preoperative hospital stay, antibiotic prophylaxis and post-operative outcomes were recorded using a structured proforma. Patients were followed during the post-operative period for the development of surgical site infection according to standard clinical criteria.

Outcome measure:
The primary outcome was the occurrence of post-operative surgical site infection following elective and emergency abdominal surgeries.

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Statistical analysis:
Data were analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentage. Comparisons between groups were performed using the Student's t-test and Chi-square test as appropriate. Variables significantly associated with surgical site infection were evaluated using multivariate logistic regression and a p-value <0.05 was considered statistically significant.

Results:
A total of 200 patients undergoing elective and emergency abdominal surgeries completed postoperative follow-up. The overall incidence of postoperative surgical site infection (SSI) was 18.5% (37/200), whereas 81.5% (163/200) of patients had an uncomplicated postoperative recovery **(Figure 1).** The overall incidence of post-operative surgical site infection (SSI) was 18.5% (37/200), while 81.5% (163/200) of patients had an uncomplicated post-operative recovery. The baseline demographic and clinical characteristics of the study population are presented in **Table 1**. The majority of patients were aged 31–45 years (31%), followed by those aged 46–60 years (29%). Males constituted 59% of the study population. Diabetes mellitus, obesity, and anemia were present in 26%, 22%, and 30.5% of patients, respectively (**Table 1**). The operative characteristics are summarized in **Table 2**. Elective procedures accounted for 61% of surgeries, whereas 39% were performed as emergency procedures. Clean-contaminated wounds were the most common wound category (41%), followed by contaminated wounds (24%), clean wounds (23%), and dirty wounds (12%). More than half of the procedures lasted ≥2 hours (52%), and 37% of patients had a preoperative hospital stay exceeding three days (**Table 2**). The association between clinical and operative variables and post-operative SSI is presented in **Table 3**. SSI occurred significantly more frequently among patients undergoing emergency surgery compared with elective procedures (64.9% vs. 33.1%, p<0.001). Similarly, SSI was significantly associated with diabetes mellitus (48.6% vs. 20.9%, p=0.002), obesity (40.5% vs. 17.8%, p=0.004), anemia (45.9% vs. 27.0%, p=0.006), operative duration ≥2 hours (67.6% vs. 48.5%, p=0.001), and contaminated or dirty wounds (62.2% vs. 30.1%, p<0.001) (**Table 3**). Multivariate logistic regression analysis identified all six evaluated factors as independent predictors of post-operative SSI **(Table 4).** Emergency surgery was associated with an adjusted odds ratio (OR) of 2.84 (95% CI: 1.39–5.82; p=0.004), while diabetes mellitus had an adjusted OR of 2.47 (95% CI: 1.18–5.17; p=0.016). Obesity (adjusted OR 2.19, 95% CI: 1.02–4.70; p=0.043), operative duration ≥2 hours (adjusted OR 2.63, 95% CI: 1.25–5.54; p=0.011), and anemia (adjusted OR 2.08, 95% CI: 1.01–4.30; p=0.047) were also independently associated with SSI. Contaminated or dirty wounds demonstrated the strongest association, with an adjusted OR of 3.58 (95% CI: 1.68–7.61; p=0.001) (**Table 4**). **Figure 2** show the distribution of the 37 SSI cases across the four wound classifications: clean, clean-contaminated, contaminated and dirty. Overall, most patients had an uncomplicated post-operative course; however, SSI developed in 18.5% of the study population. The frequency of SSI increased with the degree of wound contamination, with the greatest burden observed among patients undergoing contaminated and dirty procedures (**Tables 3 and 4**).

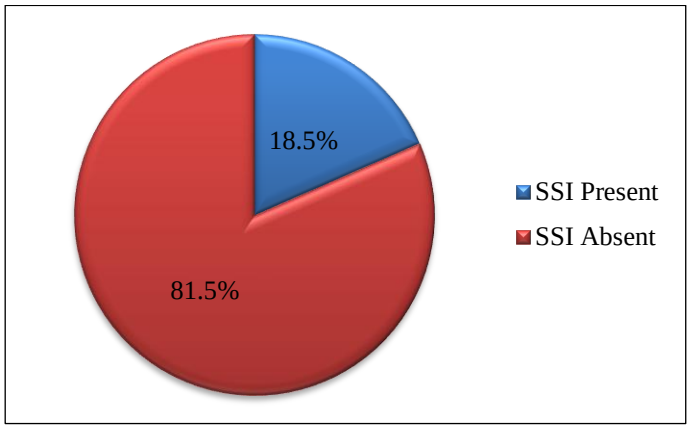


Figure 1: Overall incidence of post-operative surgical site infection

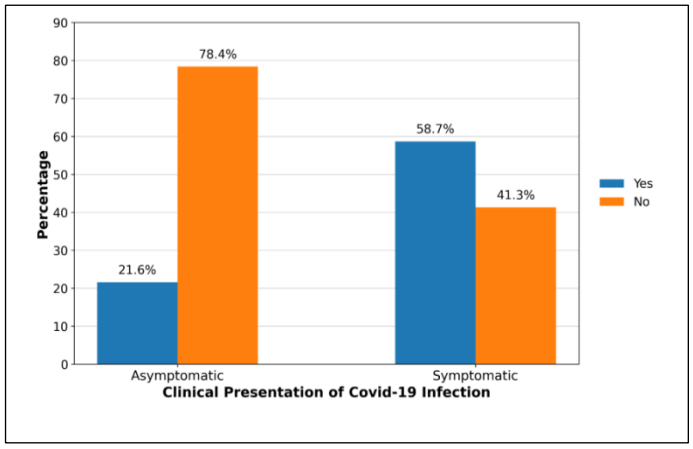


Figure 2: Distribution of surgical site infection according to wound classification

Table 1: Baseline demographic and clinical characteristics of the study participants (n = 200)

Variable		Frequency	Percentage
Age (years)	18-30	38	19%
	31-45	62	31%
	46-60	58	29%
	>60	42	21%
Gender	Male	118	59%
	Female	82	41%
BMI	Normal	92	46%
	Overweight	64	32%
	Obese	44	22%
Diabetes Mellitus	Yes	52	26%
	No	148	74%
Anemia	Yes	61	30.5%
	No	139	69.5%

Table 2: Operative characteristics of the study population (n = 200)

Variable	Frequency	Percentage

Type of Surgery	Elective	122	61%
	Emergency	78	39%
Wound Classification	Clean	46	23%
	Clean-contaminated	82	41%
	Contaminated	48	24%
	Dirty	24	12%
Duration of Surgery	< 2 hours	96	48%
	≥ 2 hours	104	52%
Preoperative Hospital Stay	≤ 3 days	126	63%
	> 3 days	74	37%

Table 3: Association between clinical variables and surgical site infection

Variable	SSI Present (n=37)	SSI Absent (n=163)	p-value
Emergency surgery	24 (64.9%)	54 (33.1%)	< 0.001
Diabetes mellitus	18 (48.6%)	34 (20.9%)	0.002
Obesity	15 (40.5%)	29 (17.8%)	0.004
Anemia	17 (45.9%)	44 (27%)	0.006
Operative duration ≥ 2 hours	25 (67.6%)	79 (48.5%)	0.001
Contaminated/Dirty wound	23 (62.2%)	49 (30.1%)	< 0.001

Table 4: Multivariate logistic regression analysis of predictors of surgical site infection

Variable	Adjusted OR	95% CI	p-value
Emergency surgery	2.84	1.39-5.82	0.004
Diabetes mellitus	2.47	1.18-5.17	0.016
Obesity	2.19	1.02-4.70	0.043
Operative duration ≥ 2 hours	2.63	1.25-5.54	0.011
Contaminated/Dirty wound	3.58	1.68-7.61	0.001
Anemia	2.08	1.01-4.30	0.047

Discussion:

The present prospective observational study evaluated the predictors of post-operative surgical site infection (SSI) among patients undergoing elective and emergency abdominal surgeries. The overall incidence of SSI was 18.5%, indicating that post-operative wound infection remains a significant complication despite advances in perioperative care and infection prevention practices. This finding is consistent with recent studies reporting a substantial burden of SSI following abdominal surgical procedures **[9, 10].** Emergency surgery was identified as a significant independent predictor of SSI in the present study. Patients undergoing emergency procedures often have delayed presentation, contaminated surgical fields and limited time for preoperative optimization, which increase the likelihood of post-operative infection. Similar findings have been reported in recent studies evaluating abdominal surgeries **[11, 12].** Diabetes mellitus, obesity and anemia were also significantly associated with the occurrence of SSI. Poor glycemic control impairs wound healing and immune function, obesity increases operative complexity and tissue trauma, while anemia reduces tissue oxygenation and delays wound healing. These findings are in agreement with recent literature identifying these comorbidities as important patient-related risk factors for SSI **[13, 14].** Operative duration of two hours or more and contaminated or dirty wound classification were found to be significant predictors of post-operative SSI. Prolonged surgery increases tissue exposure and bacterial contamination, whereas contaminated wounds carry a higher microbial load, thereby increasing the risk of infection. Similar observations have been reported in several recent studies and international recommendations **[15, 16].** The findings of the present study emphasize the importance of identifying high-risk patients before surgery and implementing preventive measures such as optimization of comorbid conditions, correction of anemia, timely antibiotic prophylaxis, meticulous surgical technique and adherence to standard infection prevention protocols. These interventions may reduce the incidence of post-operative SSI and improve surgical outcomes **[17, 18].** Overall, the present study demonstrates that emergency surgery, diabetes mellitus, obesity, anemia, prolonged operative duration and contaminated or dirty wounds are important independent predictors of post-operative surgical site infection. Early recognition and appropriate perioperative management of these risk factors can contribute to better post-operative recovery, shorter hospital stay and improved patient outcomes.

Conclusion:

Post-operative surgical site infection remains a common complication following abdominal surgeries, particularly among patients undergoing emergency procedures. Emergency surgery, diabetes mellitus, obesity, anemia, prolonged operative duration and contaminated or dirty wound classification were identified as significant predictors of SSI. Early identification and optimization of these modifiable risk factors, together with appropriate perioperative care and adherence to infection prevention protocols, may reduce the incidence of surgical site infection, improve post-operative recovery and enhance overall surgical outcomes.

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